PCT

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N 7/08	A1	(11) International Publication Number: **WO 98/41017** (43) International Publication Date: 17 September 1998 (17.09.98)

(21) International Application Number: PCT/GB98/00732

(22) International Filing Date: 11 March 1998 (11.03.98)

(30) Priority Data:
9705045.4   12 March 1997 (12.03.97)   GB

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(81) Designated States: CA, JP, KR, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
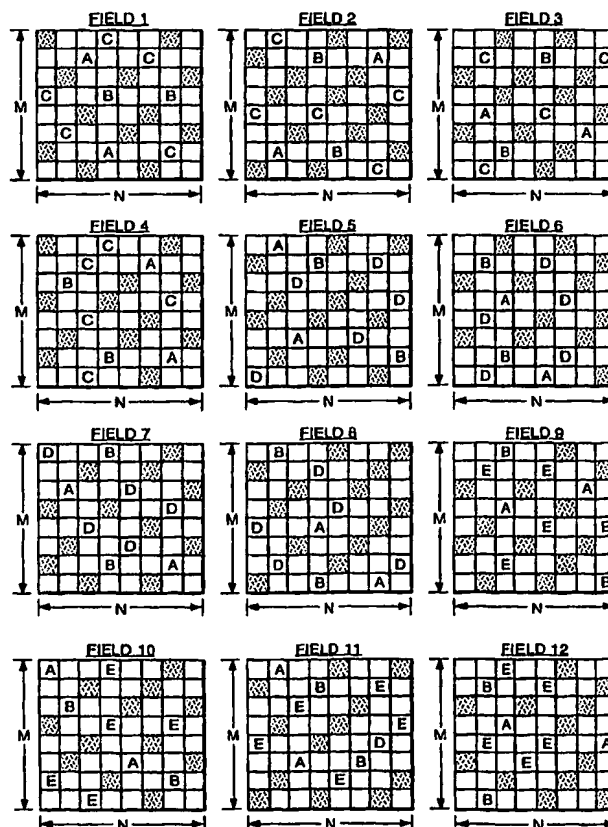
Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR CODING INFORMATION

(57) Abstract

A method and apparatus for invisibly embedding coded information in an image and decoding such information from the image. The apparatus comprises a processing means (9, 10) for analysing the image, dividing the image into a plurality of fields, and dividing each field into N*M blocks each of n*m pixels. A pattern generator (11) and sequencer (12) is provided and is operable to define a predetermined sequence of different selection patterns, each of which, in operation, selects a predetermined pattern of selected blocks (13) in a field. Each pattern in the sequence is selected such that, in operation, blocks (13) selected in each pattern are not selected in a predetermined number of successive patterns immediately following in the sequence. A block selection means (14, 16) is provided for applying the first selection pattern of a sequence to a selected field, to select blocks (13) in the selected fields. The block selection means (14, 16) is operable to apply the next successive pattern in the sequence to the next successive field to select blocks (13) in that field. Analysing means (14 to 58), for analysing each selected block in each field, is provided and is operable to identify strongly featured regions in each block. Code insertion means (80 to 84) are provided to insert coded information into said regions of each selected block.

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METHOD AND APPARATUS FOR CODING INFORMATION

The present invention relates to a method and apparatus for the insertion, and subsequent decoding, of coded information into images.

It is known to insert codes into images, for example video transmissions or video
5   clips or stills transmitted across a telecommunication link, for the purpose of identifying the owner of the images. There are a number of known schemes for inserting identification codes into the sync periods, and more recently it has been proposed to insert identification codes into the image itself, but in such a manner that the code cannot be detected by the eye.

10   WO 95/14289 discloses the embedding of an identification code throughout an image by modulating a digitised version of the image with a small noise signal. The specific system described suffers from the disadvantage of requiring to have to hand the original image for code identification. Further improvements in code robustness for transmission over telecommunications links or broadcasting are also desirable.

15   WO 95/20291 discloses a method of hiding copyright related messages with a digital data work, which relies on commonly occurring patterns or sequences of data in the work acting as signposts to target data elements which are modified according to certain rules. The disclosed method suffers from a lack of robustness to signal degradation.

Also discloses a method of hiding a copyright message within digital data works.
20   The coded information is distributed throughout the whole image by embedding the coded information in a present pattern of pixels, and no attempt is made to identify strongly featured regions of the image and insert information in these regions. Furthermore, the method is not very suited for embedded codes in a video image, because the method does not address the problem of ensuring that the same pixel in each immediate follow frame,
25   or field, of the image does not contain embedded codes. With video images, if no attempt is made to ensure the pattern of selected pixels is varied from one frame to another, the presence of embedded code will be detected and appear as a shimmer to the observer.

The above references suffer from a disadvantage that they are concerned wholly or principally with the digital domain, and the disclosed techniques are not suited to the analog domain, in particular where digital to analog conversion and analog to digital conversion may easily lose or degrade individual pixel values.

5   In our copending application PCT/GB96/00246 (our ref. PQ12632), there is disclosed and claimed a method for inserting coded information into an image, comprising analysing the image, identifying strongly featured regions and inserting coded information into these regions. Because the method relies on an analysis of the entire image and code being inserted in strongly featured regions rather than in individual pixels as in the prior

10   art, the code is better able to survive analog to digital conversions and digital to analog conversions, where there will inevitably be pixel misalignments between the original and processed images, and hence the pixel values will be apparently altered.

By "strongly featured regions" is meant regions of primary strength to which the eye responds in viewing an image for example textured regions or lines or boundaries

15   between two regions of different luminance. In such regions, it is possible to insert a relatively large amount of information without significantly altering the image in its appearance to the eye. As preferred, edge regions between areas of different luminance are employed since these are very distinctive and will permit code insertion without visibly degrading the image, and the coded information is inserted into such strongly featured

20   regions by altering the structure of the image in such region in a predictable or identifiable manner. The image is altered by applying an insert function to an area including the strongly featured region, which insert function gradually decreases in intensity from the centre of its region of application, so as to blend with the surrounding region.

A main advantage of applying the coded information by altering the image in a

25   predictable or identifiable manner is that the information can be recovered in a decoding process at a remote location without having the original to hand.

As disclosed, in our copending Application PCT/GB96/00246 (our Ref PQ12632) the image, e.g. a video frame, is divided up into a number M*N of blocks in M rows and N columns, each block comprising n*n pixel elements (e.g. 8x8). Strongly featured regions

30   are searched in each block for insertion of code. In order to encode a significant amount of

information into an image, it is necessary to apply the insertion function to a number of edges in the image. If for example, one edge is chosen in each block into which the image is divided, then in order to increase confidence when attempting to recognise the code, the edges in one row may be encoded according to two separate pseudo-random codes, representing a "1" or "0".

Prior to inserting the information, the image is assessed as to whether the image is suitable for code insertion, for example the degree of consistency of the edge, the definition of the edge centre to prevent insertions when the image is determined to be unsuitable. Problems have arisen where more than one distinct edge is present in the image, or the part of the image under consideration for code insertion; for example there may be a corner feature.

In our co-pending British Application 9616571.7, a block within an image may be selected to be encoded using an edge detection based scheme, the selection being dependant on the edge activity in the block. This allows for encoding of blocks with multiple features such as blocks containing a corner or block containing two edges. In these blocks an edge detection scheme is applied to the block to produce a function within the block which has a value at each pixel which is related to the strength of the edge at that pixel. This edge function is suitably scaled, and optionally multiplied by a circular function centred on the centre of the block. The scaled edge function is then added to the image on a pixel by pixel basis, with the sign of the function, plus or minus, representing a "1" or "0" bit of information. In a decoding operation, edges are detected and an estimate is made of the appropriate edge function. This estimate is then correlated with the image in order to reveal the existence of coded information.

The inventions disclosed in our co-pending applications PCT/GB96/00246 and British Patent Application No 9616571.7 treat each frame of a video sequence as separate entities. Codes can be embedded successfully in video still pictures and in some video film sequences without the embedded codes being detectable by the viewer. Usually each frame of a video sequence is made of two fields, one of which constitutes the even lines of the displayed image and the other the odd lines of the displayed image. The frames are separated by a syncronisation period (often referred to as the sync period). It has been

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found that in some high quality broadcast videos, the embedded code is noticeable as a slight shimmer at the edge region due to the fact that in successive fields or frames of the video image the same blocks are used to embed coded information. If the fields or frames do not align exactly, that is to say that there are slight miss-matches of each block in
5   subsequent fields of the video sequence then the viewer will see a slight shimmer at the regions where the code is embedded.

An object of the present invention is to improve the visually embedded coding capability of video by relating the encoding of one field to that of the adjacent fields such that visibility of the codes is reduced by ensuring that the same blocks used in one field to
10   carry the code are not used in a number of successive fields.

A further object is to allow the insertion of stronger codes into a video image such that their retrieval is more robust, and to allow for each bit of the information to be spread over several fields of a video sequence.

The invention as claimed herein, achieves the above mentioned objects by
15   providing methods and apparatus for encoding and decoding images by dividing the image into a plurality of fields, each of which are divided into N * M blocks of n * m pixels. A predetermined pattern of blocks are selected in each field as candidates for carrying the embedded code, but blocks selected in one field are not selected in a predetermined number of immediately following successive fields in the sequence. In this way the
20   embedded codes are less likely to produce the shimmer effect referred to above.

The encoding and decoding processes have to be synchronised because an encoded image may be presented to the decoder in a geometrically altered state from which it was encoded. The geometric transformation may be for example an offset (x,y) translation, or a scaling in one or both axes (including different scaling in each axis), or a rotation. If the
25   geometric transformation is of a significant size, then in order to decode it this geometric distortion must be accounted for. The decoder synchronising process achieves this by an analysis process involving splitting the image into fields, splitting each field into blocks, applying the patterns to each field to define selected blocks as used by the encoder, analysing the selected blocks for the type of insert and decoding the same selected blocks
30   as created by the encoder accordingly. The encoding and decoding processes produce a

measure of coded insets and their centres and the regularity of their structure. The offsets, scaling and rotations are then calculated from the geometric variations of the centres and structure during the decoding process and this is then used to correct the image before the final decoding.

5   **Brief Description of the Drawings**

A preferred embodiment of the invention will now be described with reference to the accompanying drawing in which:

Figures 1 to 9 are diagrams for explaining the preferred method and apparatus for encoding and decoding images in accordance with the present invention.

10   **Description of the Preferred Embodiment**

The algorithmic steps used in the preferred embodiment of the invention will now be explained in detail. The encoding and decoding algorithms are listed below as a sequence of steps:

Encoding Algorithm

15   1)   Split the video sequence (image) into a plurality of fields.

2)   Split each field into adjacent blocks each of $n*n$ pixels.

3)   Define a predetermined sequence of different selection patterns, each of which selects a predetermined pattern of selected blocks, each pattern in the sequence being such that blocks selected in each pattern are not selected in a predetermined

20   number of successive patterns immediately following in the sequence.

4)   Apply the first selection pattern of the sequence to a first selected field to select blocks in the first field.

5)   Apply the next successive pattern in the sequence to the next successive field to select blocks in that field.

25   6)   Repeat step 5 over a predetermined number of fields for all patterns in the sequence.

7)   Repeat steps 3 to 6 cyclically for successive fields throughout the video sequence.

8)   Define one or more subsets of the selected blocks.

9)   Calculate the dominant orientation in each selected block.

10) Calculate the amount of activity in each selected block.

     Calculate the consistency of the dominant Orientation in each selected block.

11) To encode one data bit in a selected subset of selected blocks, process each selected block within the subset as follows.

11(a) look up the next element of the PRS for the data bit

       1)   if it is a +1 set to add

       2)   if it is a -1 set to subtract

11(b) Segment the selected blocks of the subset in the following categories

       1)   a single edge/line in a dominant orientation

       2)   a low activity block

       3)   several major lines or edges

11(c) Process the selected blocks of the subset as follows:-

       1)   add/subtract an elliptical function

            i)   centred on the edge

            ii)   aligned to the block orientation

            iii) scaled by the activity in the block

       2)   add/subtract a circular function

            i)   centred on the centre of the block

            ii)   fixed strength

       3)   No insertion

12   Repeat step 11 until all the bits are encoded.

Decoding Algorithm

1)   Split the image (video sequence) into a plurality of fields.

2)   Split each field into adjacent blocks each of n*n pixels.

3)   Define a predetermined sequence of different selection patterns, each of which selects a predetermined pattern of selected blocks, each pattern in the sequence being such that blocks selected in each pattern are not selected in a predetermined number of successive patterns immediately following in the sequence.

4)   Apply the first selection pattern of the sequence to a first selected field to select blocks in the first field.

5)   Apply the next successive pattern in the sequence to the next successive field to select blocks in that field.

6)   Repeat step 5 over a predetermined number of fields for all patterns in the sequence.

7)   Repeat steps 3 to 6 cyclically for successive fields throughout the video sequence.

8)   Define one or more subsets of the selected blocks.

9)   Calculate the dominant orientation in each selected block.

10)   Calculate the amount of activity in each selected block.

       Calculate the consistency of the dominant orientation in each selected block.

11)   To decode one data bit, process each selected block in a selected subset of selected blocks as follows:-

11(a) segment the blocks in the following categories:-

       i)   a single edge/line in a dominant orientation

       ii)   a low activity block

       iii)   several major lines or edges

11(b) process the selected blocks in each subset of selected blocks as follows:-

       1)   calculate the concave/convexness of an elliptical function

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        ii)   centred on the edge

        iii)   aligned to the block orientation

        iv)   scaled by the activity in the block

    2)   calculate the concave/convexness of a circular function

        i)   centred on the centre of the block

        ii)   fixed strength

    3)   do nothing

11(c)   correlate the convex/concaveness of each selected block with the next element of the data bit 1 PRS and accumulate the result.

11(d)   correlate the convex/concave-ness of each selected block with the next element of the data bit 0 PRS and accumulate the result.

12)   Compare the data bit 1 accumulated correlation with the data bit 0 accumulated correlation. The larger of the two is the decoded data bit. The size of the correlation gives the confidence in the result.

13)   repeat steps 11) and 12) for each data bit.

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Referring now to Figure 1, the video image in which the code is to be embedded is analysed and divided into adjacent fields 1, 2, 3, 4. The field axis conventions used to describe the mathematics are shown in Figure 1. A pixel is defined by its coordinates (x, y) in each field and its luminance value is $r(x,y)$. Note the top left pixel in each field is the $(0, 0)$ pixel and that the y axis has its positive direction down the field.

Each field is segmented into $N * M$ non-overlapping blocks as shown in Figure 2, each block being of size n by n pixels. Smaller values of n or m mean that it is more likely that only a single edge will be found in any given block. It also means that more individual blocks will be available for the correlation process. Larger values of n or m mean that

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larger, and therefore more robust, insertions can be made. In practice a good choice of n and m is 8. The block axis conventions used in segmenting the field are shown in Figure 2.

A sequence of selection patterns is defined each of which selects a different group of blocks 13. A first selection pattern of the sequence of patterns is applied to the first field 1 (the nominated field) to select blocks 13, shown in Figure 3 (hereinafter called "selected blocks"). In the example shown a sequence of three selection patterns is used, although the number of patterns in the sequence may be any number. Each pattern in the example shown selects α of the blocks, and although every third block in the grid is selected, each pattern in the sequence is displaced by one block so that the blocks selected in field one are not selected in the next following two fields 2, 3. Similarly the blocks 13 selected in field 2 are not selected in the next following two fields 3, 4 and so on.

There may be any number of patterns in a sequence of patterns and each pattern may select more or less number of blocks than that selected in adjacent fields.

The patterns are applied cyclically. That is to say that the sequence of predetermined patterns may be repeated by applying the function $(cfc + I + j) \; K \; P = = 0$ where I and j are the horizontal and vertical indices of the blocks in the fields, K is a modulus, P is the number of patterns in the sequence of patterns, and cfc is a cyclic field count. When the function is true a block is selected, when it is false the block is not selected. In Figure 3 every third block is selected, the cyclic count counts 0, 1, 2, 0, 1, 2, 0, 1, 2, and so on, incrementing at each field.

To make up a bit of information, a subset of the selected blocks 13, are grouped together for each bit and each of the selected blocks is analysed and the appropriate code embedded as described below.

In some source material a short sequence of fields may have a content which is difficult to encode. This may occur if the fields have very few edges in them or if the fields are blurred or if the field is almost blank. If the subset of selected blocks which make up an individual bit are all within this short sequence of fields, retrieval of the coded information will not be very robust. In addition some video equipment such as compression and standards conversion may process the fields in such a way that some

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individual fields are either totally missing or are very distorted, whilst other fields are retained. This can occur when a compression system interpolates an entire field from its neighbours, or when a cheap standards converter drops a whole field.

In order to improve robustness of the retrieval of the individual bits in these
5   circumstances, the subset of selected blocks used for each bit is spread out over a wider number of fields. This ensures that where certain fields provide little decoding information, because of either the content of the source material or some processing it has undergone, the effect of this on any particular bit is minimised, as the correlation process for that bit will also have decoding information from other fields.

10   The number and distribution of the subset of blocks grouped together to make up each bit of information can be varied for each bit of information depending on the requirements for particular applications. Subsets which are spread over more fields will have a longer delay before they are decoded, and hence will not be able to identify the material with such high time accuracy. For example a subset spread over one second will
15   only be able to identify material to one second accuracy, and will not be able to detect reliably edited clips shorter than two seconds. Subsets which have more blocks will be more robustly retrieved after passing through video processing equipment.

Since different applications have different requirements. and indeed most applications have multiple requirements, the grouping of selected blocks 13 is such that
20   the different bits of information use different numbers of selected blocks 13 and distributions of subsets. Each distribution of selected blocks 13 and subsets is known to both encoder and decoder.

As an example, an ownership identification can be encoded into the material by spreading the blocks 13 over 5 fields, and using 20% of the available blocks in each field.
25   This identification is repeated every 5 fields, and hence any 10 fields (<0.5 sec) will contain the ownership identification. Additional data is also encoded, by spreading the blocks over 50 fields (1 sec for PAL) using 70% of the available blocks in each field. This additional data may contain information such as time and date of encoding and material identification number, but can not be reliably retrieved from edited clips of less than 2

seconds. The final 10% of the blocks available in each field may be split between 5% used to carry a copy protection flag and 5% used to carry a film certification classification, and these may be spread over 500 fields (10 seconds for PAL). Figure 3 illustrates the principle, for illustrative purposes, and neither the exact pattern of the blocks nor the

5   number of fields for which each pattern continues is meant to be anything more than one example.

In Figure 3 the blocks marked A carry copy-protection information over 100 fields, the blocks marked B carry certification information over 100 fields, the blocks marked C carry ownership details (first insert) over 4 fields blocks marked D carry ownership details

10   (2nd insert) over 4 fields, blocks marked E carry ownership details (third insert) over 4 fields and the shaded blocks carry time/date and other data over 25 fields.

With the proposed invention it would be possible to use a cheaper decoder which only processes those subsets of blocks 13 that go to make up one or more sets of data bits. This cheaper decoder could be one which cannot decode the full set of data embedded in

15   the image but only a limited set of data, for example, the ownership details. The advantage of using a cut-down version of the decoder is that, since it is only required to process fewer blocks, it requires less computation and this reduces manufacturing costs. Such a cut-down decoder for example for copy protection decoding would only require 5% of the processing power of a full decoder.

20   The code to be embedded in the selected blocks 13, is inserted and decoded in exactly the same way as described in our co-pending patent applications Nos PCT/GB96/00246 and British Patent Application 9616571.7. For completeness in this specification, the processes for encoding and decoding each of the selected blocks 13 is described below.

25   In accordance with a preferred embodiment of the invention, hidden local insertions are embedded in edges within the image. Edge regions are known to have masking properties because of the way the human visual system works. In particular the local orientation of the edges are improtant, and there are specific structures in the primary

visual cortex for detecting both the presence of an edge and its local orientation (to a resolution of about 32 difference orientations).

The insertions are such that they do not alter the local orientation. They must also survive low pass filtering since this is a common process used in the processing of images.

5   The insertions are made along the length of a local section of edge, and make the grey level gradient along the direction of the edge either a concave or a convex function over the distance of the insertion i.e. travelling from a start to the end point of the insertion along the direction of the edge of the grey level is either greater or less than would be expected by a simple linear interpolation from the start and end points. One important

10   point of this is that at the start and end points the grey level must return to the value of the original image in order to prevent any propagation of the distortion, or any discontinuities.

The insertions are made as a 2D function, by using an ellipse which is aligned to the local orientation. The ellipse has a cross sectional function which is a ½ cycle of a cosine function and is used to weight the extent of the insertion, i.e. outside the ellipse no

15   insertion is made, within it the insertion is weighted by the cosine function. This gives the concave or convex function by adding or subtracting it to the image. The magnitude of the insertion can be varied according to the amount of activity in each selected block; for a high activity block a stronger insertion can be buried. It is not always possible to produce the required function; a block which already has a very strong convex function may

20   require the insertion to be very large to convert it to a concave one, and this may produce a visible artefact. This is one of the reasons for using an accumulation of a number of blocks to produce a single bit (see below).

The size of the insertions and their positions are fixed by processing the image in a block by block manner, typically with a block size of 8 by 8 pixels.

25   There may be insufficient selected blocks 13 within an image which have an edge to generate a consistent result, particularly since the selection of these edge blocks may be inconsistent when the images are processed. This can lead to problems in keeping the decoding process in synchronisation with the encoding process, such that the correct blocks are used to determine each bit.

To overcome this, the synchronisation processes of this coding and decoding is aligned to the start of a subset of blocks 13. Thus all the blocks on one subset of the selected blocks 13 are used to encode/decode the first bit. Then all the blocks within a second subset of the selected blocks 13 would encode/decode the second bit etc. This may

5   be extended so that a subset of blocks is used to encode/decode each bit, which reduces the amount of information which could be inserted but improves the robustness to processing.

In a modification, and as preferred, a subset of blocks 13 contributing to a single bit may be distributed throughout an image according to a predetermined pattern. This has the advantage as compared with a line of selected blocks contributing to a bit, that at least

10   some of the selected blocks may be sited where strongly featured regions occur, and all, are not located for example in a background region with no strong features.

To improve the accumulation of results from the individual blocks to determine a single bit, a psuedo random sequence (PRS) (but fixed sequence) of +1 or -1 is used. A +1 means that the insertions is added to produce a convex functions, and -1 means that it is

15   subtracted to produce a concave function. For the encoding process, each selected block is processed in turn, and the next element in the PRS determines whether the insertion is added or subtracted. There are two different sequences, one for the 1 data bit and one of the 0 data bit. Thus for the decoding process the concave/convex-ness of each selected block is correlated with both sequences, and the sequence which produces the highest

20   correlation determines what the decoded data bit is.

A second method of coding is to code low-pass regions as well as edge regions. The low-pass regions are coded with circular insertions centred on the selected block. The insertions in this case are of a fixed strength, and not related to the activity in the block. This improves the robustness of the process.

25   Referring to Figure 4, the local orientation for each point in each selected block 13 is calculated from four surrounding points by a process as described below. This gives a vector at each point in the selected block, with the magnitude of the vector representing the strength of the feature, and the angle representing twice the local orientation. This is illustrated in Figure 4. Thus the local orientation gives a measure of gradient of luminance

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in a particular direction within a selected block 13. A very large value of orientation indicates the existence of an edge; In this double angle form the vectors can be vector averaged over a block to give the local orientation for the selected block 13. This provides a relatively fast estimating algorithm.

5   e.g, as shown in Figure 4:

$\theta \sim -45\text{degrees}$: by convention, θ is associated with point a $= (x,y)$

$-dx \sim 0.7$

$-dy \sim -0.7$

θ is estimated from

$$a = r(x,y)$$
$$b = r(x,y+1)$$
$$c = r(x+1,y)$$
$$d = r(x+1,y+1)$$
$$e = d - a$$
$$f = b - c$$
$$Re = -2 * e * f$$
$$Im = e^2 - f^2$$
$$\theta = \frac{1}{2} Tan^{-1}\left(\frac{Im}{Re}\right)$$

θ is in single angle form

10   Re,Im are in double angle form

orientations are averaged in the Re,Im double angle form.

The calculation of the average block vector is simply a matter of summing the local vectors for the selected block, as shown in Figure 5. A large average block vector indicates a strong edge running through the block. The average energy in the block can be

15   calculated by summing the magnitudes of the individual vectors. From these two figures, the local block orientation can be calculated by taking ½ the angle of the block vector, and a measure of block consistency calculated by taking the ratio of the magnitude of the block vector to the block energy.

15

The local energy can be used to distinguish between selected blocks which have small activity (little variations in image) and selected blocks which have some activity. The consistency measure can be used to distinguish between blocks which have a consistent orientation and these which have a inconsistent orientation. This allows the

5   blocks to be split into three categories as shown in Figure 6.

For selected blocks 13 with a consistent local orientation a centre of the edge needs to be calculated. The method is shown below with reference to Figure 5. Each individual vector is resolved into a component in the same orientation as the block orientation. Then the local centroid of these components is calculated in the orthogonal axis of the local

10   orientation. This local centroid is the centre of the edge which is used to centre the insertion on the edge. During the calculation a variance is also calculated, which is used to determine if there are two edges in the same selected block, in which case the selected block is classified as inconsistent, and no insertion is made. This is to prevent the insertion being made half way between the two edges. An alternative strategy in this case would be

15   to split the insertion and make two insertions, calculating the centres by a binary splitting local centroid algorithm.

Referring to Figure 5, the orientations are held as the real $Re(x,y)$ and imaginary $Im(x,y)$ components of the double angle form

they are averaged in this form

$$Re\_A = \sum_{x,y} Re(x,y)$$

20

$$Im\_A = \sum_{x,y} Im(x,y)$$

The energy of the selected block is calculated from

$$Strength = M\_A(k,l) = \sum_{x,y} sqrt\ (\ Re(x,y), Im(x,y)\ )$$

The local block orientation is calculated from

$$\theta(k,l) = \frac{1}{2} Tan^{-1}\left(\frac{Im\_A}{Re\_A}\right)$$

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The block consistency is calculated from

$$\beta(k,l) = \frac{\text{sqrt}(\ Re\_A * Re\_A\ +\ Im\_A * Im\_A)}{M\_A(k,l)}$$

To calculate the centre point c(x,y)

translate coordinates to centre of block

$$x1 = x - \frac{N}{2}$$
$$y1 = y - \frac{N}{2}$$

5

rotate axis to local orientation

$$x2 = dx * x + dy * y$$
$$y2 = -dy * x + dx * y$$

calculate component of activity in block orientation

$$r = dx * \sin(\theta(x,y)) + dy * (-\cos(\theta(x,y)))$$

10   calculate local centroid of components

$$lcx = \frac{\sum_{x,y}(r * x2)}{\sum_{x,y}(r)}$$

$$lcy = \frac{\sum_{x,y}(r * y2)}{\sum_{x,y}(r)}$$

rotate and translate coordinates back

$$cx = dx * lcx - dy * lcy + \frac{N}{2}$$
$$cy = dy * lcx + dx * lcy + \frac{N}{2}$$

also calculate a variance figure

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$$var = \frac{\sum_{x,y}(r * y2 * y2 - lcy * lcy)}{\sum_{x,y} r}$$

Figure 6 illustrates how the different block types are processed. The oriented blocks are given an elliptical insertion aligned with the edge within the block. The strength

5   of the insertion is scaled by the energy within the block. The low energy blocks have a circular insertion, centred on the centre of the block, and with a fixed strength. They may also have a small dither to prevent contouring. Inconsistent blocks have no insertion.

The elliptical insertion function is calculated for each point within the block based on its distance from the centre point, by rotating to align a local axis with the block

10   orientation, and scaling the y-axis to produce an elliptical rather than circular function, as shown in Figure 6. The cross sectional function of the insertion is a 1/2 cycle of a cos function. This insertion function is then used to weight the concave/convex-ness of the individual points, so as to limit the extent of the insertion.

Referring to Figure 7, the insertion function is calculated as follows. Calculate the

15   distance vector between point (x,y) and point (cx,cy)

$$x1 = x - cx$$
$$y1 = y - cy$$

Rotate the local axis to align with the local block orientation

$$x2 = dx * x1 + dy * y1$$
$$y2 = -dy * x1 + dx * y1$$

scale the y axis to produce an elliptical function in distance

20                                    $$y3 = y2 * ratio$$

calculate the radial distance of the point(x,y)

$$d = \frac{\sqrt{x2^2 + y3^2}}{MAX\_d}$$

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calculate the insertion function

$$if(d > 1)d = 1$$
$$i(x,y) = 0.5*(\cos(d*\pi)+1)$$

The insert function is appropriately scaled by the block energy factor, M_A. Whilst the scaling may be a simple proportionality factor, other scalings may be envisaged. In general, the scaled insert factor, i_S, may be represented as:

$$(i(x,y), M\_A) i_S(x,y) = f$$

The calculation of the convex/concave-ness of a block is illustrated in Figure 8. The edge points of each selected block are used to estimate the inside points using a linear interpolation in the direction of the block orientation. The difference between the estimated value and the actual value then gives a +ve or -ve number. These numbers are then weighted by the insertion function and summed over the block to give a final +ve or -ve value for the block which indicated its concave or convex-ness.

Referring to Figure 7, predicted value at point (x,y)

$$p(x,y) = Lin(p(x1,y1),p(x2,y2))$$
$$p(x1,y1) = Lin(r(x11,y1),r(x12,y1))$$
$$p(x2,y2) = Lin(r(x2,y21),r(x2,y22))$$

concave/convexness of point (x,y)

$$c(x,y) = r(x,y) - p(x,y)$$

Overall concave/convexness of block(k,l), when scaled insert function is added:

$$C(k,l) = \sum_{x,y} c(x,y)*i_s(x,y)$$

The measure C of block concavity is a significant factor which is computed during the encoding process, and is employed during the decoding process to derive the inserted code.

In the encoding process, the measure C is computed , and a further factor is computed from C, as will be explained in more detail below to determine by how much

the scaled insert function should be further scaled to produce the desired value of C in the individual encoded pixels which are transmitted.

In the decoding process, the existing concavity C of the image block is assessed (which will include the inserted scaled insert function), and to this is added the concavity of the predicted insert function i_S. A correlation process is then employed to determine whether an insert function exists within the image.

By way of example, in a decoding process, measures of block concave/convex-ness are combined across a predefined subset of blocks in order to produce a reliable result for each bit. For example the measures from 4 successive selected blocks of the subset can be combined to produce each bit. The combination is done by correlating to one of two different pseudo-random sequences as shown below. The elements of the PRS are multiplied by the measures for successive blocks in the subset, and the results accumulated. This is done for both sequences. Then the largest of the two determines which bit is decoded, and ratio of the largest correlating value to the maximum possible one gives a measure of confidence that the correlation is correct. Note that a measure of confidence is only reliable for a large number of blocks in the subset.

EXAMPLE

- two correlation sequences e.g.

Zero : +1, -1, +1,+1, -1, +1, +1, +1, -1, -1, +1

One: -1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1

- correlated with C(x,y) e.g.

C(x,y): +0.2, -0.9, +0.1, etc...

zero gives: $(+1)*(+0.2) +(-1)* (-0.9) + (+1)* (+0.1) = +1.2$

one gives: $(-1)*(+0...2) + (-1)*(-0.9) + (-1)*(+0.1) = +0.6$

sum gives: $(+0.2) + (+0.9) + (+0.1) = +1.2$

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- Maximum of zero or one determines 0 or 1 bit decision

e.g. zero = +1.2 gives a 0 bit

- 100* (zero/sum) gives measure of confidence as a number up to a maximum of 100

e.g. 100* (zero/sum) = 100

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Referring now to Figure 9, which shows an encoder for encoding video images, video data is input on line 8 to a field generator 9 which effectively defines a plurality of fields and to a block defining device 10 which performs the task of dividing each field into a grid of blocks each of sixty four pixels. The block data is then processed by a pattern

10 generator 11 and pattern sequencer 12 which serves to select a pattern of selected blocks 13 and the sequencer 12 defines subsets of the selected blocks 13. The data for each selected block is passed to two devices 14, 16 for estimating the local orientation of each point within a selected block and giving the real component Re_A of the orientation and the imaginary component Im_A of the orientation by a process of interpolation described

15 with reference to Figure 4. The values are averaged in summing devices 18, to give average values for each selected block and from these average values, the block orientation θ is calculated as at 22 by dividing the angle of the block vector by two as described with reference to Figure 5. Signals Im_A and Re_A are applied as inputs to an energy calculation unit 68 which generates a signal Strength, representing the energy or strength

20 of the featured regions in the selected block, in the manner described with reference to Figure 5. A measure of the consistency of orientation in the selected block is obtained as at 24 by taking the ratio of the magnitude of the block vector to the block energy. This provides an output β which is applied to a logic unit 80 to be described.

The block orientation unit 22 output θ is applied to devices 26, 28 together with the

25 individual values of each vector from units 14,16 in order to perform the calculation described with reference to Figure 5 of calculating for each vector the component of activity parallel to the axis of the block orientation. In addition, device 28 rotates the coordinates of the vectors to be parallel with the block orientation vector. The centroid of the components is computed as at 30, 32 and outputs lcx, lcy are applied to unit 34 which

is operative to translate the components back to the original x, y axes and provide centroid components cx, cy. In addition device 36 calculates a variance figure, var, as described with reference to Figure 5.

Devices 40, 42, 44 receive signals cx, cy, the block orientation θ, and the Strength

5   signal. Devices 40, 42, 44 are operative to calculate the elliptical insertion function i as described with reference to Figure 7. The Strength signal is employed to scale the insert function and produce a scaled insert function i_s. The insertion function is employed to weight the amount of luminance applied to each pixel dependent on its radial position with reference to the edge centre.

10   Devices 46, 48, 50, 52, 54, 56 are employed to interpolate the pixel addresses of the edge and to estimate the existing concavity of the block. Firstly, a point within the block (x,y) is reconstituted from the orientation θ as at 46, 48. As described with reference to Figure 7, edge addresses x11 - x22 are estimated at 50 by a process of interpolation at the edge of the block, and the luminance values $p(x_1, y_1)$, $p(x_2, y_2)$ are then estimated as

15   at 52, 54 by a process of linear interpolation. The luminance of the point p(x, y) is then calculated by a further linear interpolation as at 56. The difference c(x, y) between the actual value r(x, y) and the estimated value p(x, y) is then found in subtractor 58. The value c(x, y) weighted by the insertion function i(x, y) and summed at 60 over the entire block gives a sum value C(k,l) representing the concavity of the entire block as described

20   above.

As mentioned above, this value is employed directly in the decoding process. In the encoding process, this value is employed, as will now be described, to determine the weighting to be applied to the luminance of individual pixels. A value is derived representing the maximum strength of the insert which will not risk the insert becoming

25   visible. This value is derived from a look up table 70 which is accessed by the Strength signal. The lookup table value is limited as at 72 and modulated as at 74 by the pseudo random code bit to be applied to the block. The result is then subtracted from the overall concavity figure C in subtractor 62. The result of the subtraction gives a multiplying factor representing by how much the insert function must be adjusted to give the appropriate

30   luminance value for individual pixels. This value is limited at 78. If the multiplying factor

is too great, creating the risk of a visible artefact, then the limiter 78 will return a maximum value only.

The multiplying factor is subject to a logical function at 80 which receives a control input from a logic block 81, which thresholds and combines inputs comprising the consistency angle β, the variance var, and the signal Strength from unit 68 to indicate whether the block is a suitable block for containing data. Effectively the units 80, 81 perform the function indicated in Figure 5 to assess whether the selected block is suitable for code insertion.

The scaled insert function i_s is multiplied at unit 82 with the multiplying factor and summed at 84 on a pixel-by-pixel basis with the input data from unit 12 to provide a coded output signal as at 84.

In the case where a selected the block 13 is unsuitable for code insertion along an edge, in that the Strength signal indicates that the selected block 13 is of low activity as exemplified in Fig. 5b, then units 40-44 are adapted to compute a circular insert function. In the case where as indicated in Figure 5a, insertion along an edge is possible, then units 40 - 44 compute the elliptical insertion function i_s defined above with reference to Figure 6.

Referring now to Figure 10, the decoding section, which receives the coded output from the encoder, operates in a very similar manner and similar units are indicated by the same reference numeral. The essential difference is that units 70 - 82 of the encoder are omitted and are replaced in the decoder by unit 100, which is operative to perform the correlation function outlined above (see EXAMPLE) with the pseudo random codes in order to decode the data. Thus the decoder computes the overall concavity of the block as at 58, and the anticipated scaled insert function i_s These values are summed as at 60 to give a value for the whole block, and a correlation is performed in unit 100 with the two pseudo random codes representing the two possible binary values.

Whilst the above has been described as a preferred embodiment, other embodiments may be implemented. For example an embodiment will now be described for encoding textured regions.

ENCODER

1. An image is to be encoded containing textured regions comprising a random mixture of small localised areas having different chrominance values. For each field of the MxN blocks of the image, the texture statistical parameters are calculated by a cluster analysis process which produces clusters of chrominance values and the variance values for each cluster in each field. The number of clusters and cluster variances are used to identify blocks which consist of two (or more) basic chrominance values (colours) which are distributed in a random or relatively random pattern. The computed statistical parameters are used to identify the more intense "foreground" value. A threshold is set based on the statistical parameters, and used to identify pixels within all the blocks in the textured region of the field which belong to the foreground value.

2. A circular function centered on the centre of one of the blocks in the textured region of the field, with a maximum value at its centre and tapering to zero with an appropriate cross-sectional function, a 1/2 wave raised cosine function, is calculated. The magnitude of the circular function is set from the cluster statistics (by means of empirical measurements), to maximise the insertion strength whilst limiting visibility. It is also limited by the existing concavity/ convexity of the selected subset block, which is calculated as in the above described embodiment.

3. The insertion function thus calculated is applied to adjust the cluster value in a selected block 13 within the textured region of the field in a positive or negative manner depending on the existing concavity, according to the required sign. The adjustment is made only to those pixels in the selected block which have been identified as part of the foreground value of the textured region.

DECODER

1. As with step 1. of the Encoder, the statistical parameters of the all blocks in the textured region of the field are calculated to identify the "foreground" pixels.

2. For each identified foreground pixel , the distance from the centre of the selected block (circular insert function) is calculated.

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3. All different combinations of pairs Pi of foreground pixels are determined, and for each pair Pi the nearer pixel to the centre is calculated. The difference in the intensity values Vi of each pair is computed by subtracting the value of the pixel nearer the centre from the value of the pixel further from the center. The difference Di in the distances of the pixels of each pair from the centre is also calculated.

4. A factor C is now computed $= \Sigma_i\ Vi*Di$

5. C is now the estimate of concavity and is used as in the main embodiment as described above.

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CLAIMS

1.   A method of invisibly embedding coded information in an image comprising the steps of

(a)   analysing the image,

(b)   dividing the image into a plurality of fields,

(c)   dividing each field into N*M blocks each of n*m pixels.

(d)   defining a predetermined sequence of different selection patterns, each of which selects a predetermined pattern of selected blocks in a field, each pattern in the sequence being such that blocks selected in each pattern are not selected in a predetermined number of successive patterns immediately following in the sequence.

(e)   applying the first selection pattern of the sequence to a selected field to select blocks in the selected field.

(f)   applying the next successive pattern in the sequence to the next successive field to select blocks in that field.

(g)   repeating step (f) over a predetermined number of fields for all patterns in the sequence.

(h)   analysing each selected block in each field and identifying strongly featured regions in each selected block, and,

(i)   inserting coded information into said regions of each selected block, and,

(j)   repeating steps (d) to (i) for a predetermined number of fields.

2.   A method of encoding an image according to claim 1 wherein the sequence of patterns is repeated cyclically over a predetermined number of fields.

3.   A method of encoding an image according to claim 2 wherein the sequence of patterns is repeated cyclically and blocks are selected according to the function

$$(cfc + 1 + j) \, KP = = 0$$

where I and j are the horizontal and vertical indices of the blocks in a field, K is a modulus, P is the number of patterns in the sequence, cfc is a predetermined cyclic field count, and blocks are selected when the function is true and not when the function is false.

5   4.   A method of encoding an image according to claim 2 or claim 3 wherein more than one subset of blocks are selected in each field, and the blocks in each subset are embedded with a bit of code pertaining to one set of information, and the blocks in another subset are embedded with a bit of code pertaining to another set of information.

5.   A method of encoding an image according to any one of claims 1 to 4, wherein the
10   strongly featured regions comprise edge regions between areas of different luminance and/ or chrominance.

6.   A method of encoding an image according to claim 5, wherein the strongly featured regions comprise textured regions having distributed therein localised areas of different luminance and/or chrominance values.

15   7.   A method of encoding an image according to claim 6 comprising analysing a textured region of a field of the image by a process of cluster analysis, identifying a cluster of foreground local areas with a predetermined quality within the textured region of the field, and modifying the chrominance and, or, luminance values within one or more selected blocks located within the textured region of the field with an insert function,
20   which decreases in intensity from its centre, for representing one of two binary values.

8.   A method of encoding an image according to claim 7 wherein the insert function is circular in extent, centred on the geometric centre of the cluster within the textured region of the selected block.

9.   A method of encoding an image according to claim 5, including the step of
25   inserting along a length of the edge region of a selected block an insert function whose intensity varies in a non-linear manner, for representing one of two binary values.

10.   A method of encoding an image according to claim 9, wherein the insert function is elliptical in extent, with its intensity gradually decreasing in a direction along its major axis, and with its major axis extending along the length of the edge.

11.   A method of encoding an image according to claim 10, wherein the elliptical function is centred on the centre of the edge within a selected block.

12.   A method of encoding an image according to any of claims 5 to 7, wherein the insert function varies in intensity in a concave manner.

13.   A method of encoding an image according to any one of claims 1 to 12, including identifying a masking parameter for a region in a field of the image, and limiting the intensity of the inserted code in each selected block within that region in accordance with the masking parameter.

14.   A method of encoding an image according to claim 13, wherein the masking parameter determination includes assessing the image as to the degree of strength or energy of the strongly featured region within the image, and determining the intensity of the code to be inserted in a selected block in dependence on such strength assessment.

15.   A method of encoding an image according to claim 13, including assessing a region of a field of the image as to whether the region contains an image function of a type similar to an insert function to be inserted in selected blocks within the region, and assessing the intensity of the image function.

16.   A method of encoding an image according to claim 15 wherein, if the said region of the field of the image contains said image function, the sum of said image function and the insert function is limited if the intensity of the image function is higher than a predetermined value.

17.   A method of encoding an image according to claim comprising the step of determining for at least one region of a field of the image a masking parameter, and inserting into one or more selected blocks located in said region, coded information in a predictable and identifiable manner by an amount limited in accordance with said masking parameter.

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18.   A method of encoding an image according to any of claims 13 to 16, wherein the masking parameter determination includes determining whether the strongly featured region of a field of the image is sufficiently well defined to permit insertion of coded information into a selected block in said region of the image.

5   19.   A method of encoding an image according to claim 1, including the step of calculating an insert function to be added to the luminance of each pixel within a selected block based on the distance of the pixel from the central point of the edge.

20.   A method of encoding an image according to claim 19, wherein an assessment is made of each selected block to assess, whether it has a single strongly featured region, has 10   several strongly featured regions, or is a block having low activity in terms of image information.

21.   A method of encoding an image according to claim 19, wherein if a block is assessed to have a low activity, a code is inserted into the block defined by a geometric region where the pixels within the region have a luminance modulated according to a 15   predetermined function.

22.   A method of decoding invisibly embedded coded information in an image comprising the steps of

(a)   analysing the image,

(b)   dividing the image into a plurality of fields,

20   (c)   dividing each field into N*M blocks each of n*m pixels.

(d)   defining a predetermined sequence of different selection patterns, each of which selects a predetermined pattern of selected blocks in a field, each pattern in the sequence being such that blocks selected in each pattern are not selected in a predetermined number of successive patterns immediately following in the 25   sequence.

(e)   applying the first selection pattern of a sequence to a selected field to identify selected blocks in the selected field.

(f)   applying the next successive pattern in the sequence to the next successive field to identify selected blocks in that field.

(g)   repeating step (f) over a predetermined number of fields for all patterns in the sequence.

(h)   analysing each identified selected block in each field and identifying strongly featured regions in each selected block, and,

(i)   decoding information contained in said regions of each selected block, and,

(j)   repeating steps (d) to (i) over a predetermined number of fields.

23.   A method of decoding an image according to claim 22, including the step of determining the intensity of an anticipated insert function in accordance with a masking parameter based on the strength or energy of a strongly featured region of the overall image.

24.   A method of decoding an image according to claim 22, including assessing each selected block as to whether the block contains a function of the type of which the coded information is inserted, assessing the degree of such function, and correlating an anticipated insertion with the image.

25.   A method of decoding an image according to claim 22, comprising analysing a textured region of a field of the image by a process of cluster analysis, identifying a cluster of foreground local areas with a certain quality, and determining whether there exists a selected block located within the textured region having an insert function consisting of a modification of the chrominance and/or luminance values of a cluster which decreases in intensity from its centre for representing one of two binary values, and decoding the binary values.

26.   A method of decoding an image according to claim 25, wherein the insert function is circular in extent, and is centred on the geometric centre of the cluster.

27.   A method of decoding an image according to claim 22, including the step of determining whether there exists along a length of an edge region within a selected block,

an insert function whose intensity varies in a non-linear manner, for representing one of two binary values, and decoding the binary values.

28. A method of decoding an image according to claim 22, wherein a subset of selected blocks, selected according to said sequence of selection patterns, are decoded according to a pseudo random sequence, the blocks in the subset representing one or more bits of information.

29. A method of decoding an image according to claim 22 including the step of determining if a block has a low activity, and detecting a code inserted into the block defined by a geometric region where the pixels within the region have a luminance modulated according to a predetermined function.

30. Apparatus for invisibly embedding coded information in an image comprising, image processing means for analysing the image, dividing the image into a plurality of fields, and dividing each field into N*M blocks each of n*m pixels, pattern defining means operable to define a predetermined sequence of different selection patterns, each of which, in operation, selects a predetermined pattern of selected blocks in a field, each pattern in the sequence being such that, in operation, blocks selected in each pattern are not selected in a predetermined number of successive patterns immediately following in the sequence, block selection means for applying the first selection pattern of a sequence to a selected field to select blocks in the selected field, said block selection means being operable to apply the next successive pattern in the sequence to the next successive field to select blocks in that field block analysing means for analysing each selected block in each field and operable to identify strongly featured regions in each selected block, and code insertion means operable to insert coded information into said regions of each selected block.

31. Apparatus for encoding an image according to claim 30 wherein the pattern defining means is operable to repeat the sequence of patterns cyclically for a predetermined number of fields.

32. Apparatus for encoding an image according to claim 31 wherein the blocks are selected according to the function

$$(cfc + I + j) \ KP = = 0$$

where I and j are the horizontal and vertical indices of the blocks in a field, K is a modulus, P is the number of patterns in the sequence, cfc is a predetermined cyclic field count, and blocks are selected when the function is true and not when the function is false.

33.   Apparatus for encoding an image according to any one of claims 30 to 32 wherein more than one subset of selected blocks are selected in each field, and the code insertion means operates on each subset to insert a bit of code pertaining one set of information and to insert into blocks in another subset being embedded a bit of code pertaining to another set of information.

34.   Apparatus for decoding an image according to claim 33, wherein the image processing means is operable to identify edge regions between areas of different luminance and/ or chrominance.

35.   Apparatus for encoding an image according to claim 33, wherein the image processing means is operable to identify textured regions of a field of the image having distributed therein localised areas of different luminance and/or chrominance values.

36.   Apparatus for encoding an image according to any of claims 30 to 35, wherein the inserting means is operable to alter the structure of the image in a predictable or identifiable manner so that the coded information can subsequently be retrieved without reference to the original image.

37.   Apparatus for encoding an image according to claim 36, wherein said image processing means is operable to analyse a textured region of a region of a field of the image by a process of cluster analysis, by identifying a cluster of foreground local areas with a certain quality, and the inserting means is operable to modify the chrominance and/or luminance values of the cluster of a selected block within said region with an insert function which decreases in intensity from its centre, for representing one of two binary values.

38   Apparatus according to claim 37, wherein said code insertion means is operable to insert along a length of the edge region an insert function whose intensity varies in a non-linear manner, for representing one of two binary values.

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39.   Apparatus according to claim 38, wherein the insert function is elliptical in extent, with its intensity gradually decreasing in a direction along its major axis, and with its major axis extending along the length of the edge.

40.   Apparatus for encoding an image according to claim 39, wherein the elliptical function is centred on the centre of the edge.

41.   Apparatus according to any of claims 30 to 38, wherein the insert function varies in intensity in a concave manner.

42.   Apparatus for encoding an image according to claim 30, wherein the image processing means includes means for identifying a masking parameter for the image, and limiting the intensity of the inserted code in accordance with the masking parameter so that the inserted code is invisible.

43   Apparatus for encoding an image according to claim 42 wherein the image processing means includes means for determining for at least one such region a masking parameter, and means for inserting coded information into such region in a predictable or identifiable manner by an amount limited in accordance with said masking parameter.

44.   Apparatus according to claim 43, wherein the means for determining the masking parameter includes means for assessing the image as to the degree of activity or energy within the image.

45.   Apparatus according to claim 43 or 44, wherein the means for determining the masking parameter includes means for assessing the image as to whether the image overall contains a function of the type of which the coded information is inserted, and assessing the degree of such function.

46.   Apparatus according to claim 30, wherein the insertion means is operative to insert coded information employing a concave function.

47.   Apparatus according to claim 45, including means for limiting the total intensity if the sum of the intensity of the coded information and the intensity of the function in the overall image is too great.

48. Apparatus according to any of claims 42 to 47, wherein the masking parameter means includes means for determining whether the strongly featured region is sufficiently well defined to permit insertion of coded information.

49. Apparatus according to claim 48, wherein the code insertion means includes means for encoding a subset of the selected according to a pseudo random sequence so that the blocks in the subset represent one or more bits of information.

50. Apparatus according to claim 49, wherein theimage processing means includes means for calculating an insert function to be added to the luminance of each pixel within the block based on the distance of the pixel from the central point of the edge.

51. Apparatus for encoding an image according to claim 54, wherein the image processing means is operable to assess the type of image within each selected block, whether it has a single strongly featured region, has more than one strongly featured region, or is a block having low activity in terms of image information.

52. Apparatus according to claim 57 wherein the code insertion means is arranged to insert a code into a block assessed to have a low activity, the code defined by a geometric region wherein the pixels within the region have a luminance modulated according to a predetermined function.

53. Apparatus for decoding invisibly embedded coded information in an image comprising analysing means for analysing the image, dividing the image into a plurality of fields,and dividing each field into N*M blocks each of n*m pixels, pattern defining, means operable to define a predetermined sequence of predetermined different selection patterns, and thereby select a predetermined pattern of selected blocks in a field to be decoded, said patterns in the sequence being such that blocks selected in each pattern are not selected in a predetermined number of successive patterns immediately following in the sequence, pattern selection means operable to apply the first selection pattern of a sequence to a selected field to identify selected blocks in the selected field and said block selection means being operable to apply the next successive pattern in the sequence to the next successive field to identify selected blocks in that field, and decoding means operable to analyse each identified selected block in each field, identify strongly featured regions in

each selected block where an anticipated insert of coded information may be embedded locate said insert within said selected block, and, decode information contained in said insert.

54   Apparatus for decoding an image according to claim 53 wherein the pattern defining means is operable to repeat athe sequence of patterns cyclically for a predetermined number of fields.

55   Apparatus according to claim 53 wherein the pattern defining means is operable to seect blocks according to the function

$$(cfc + I + j) KP = = 0$$

where I and j are the horizontal and vertical indices of the blocks in a field, K is a modulus, P is the number of patterns in the sequence, cfc is a predetermined cyclic field count, and blocks are selected when the function is true and not when the function is false.

56.   Apparatus for decoding an image according to any one of claims 53 to 55, wherein the decoding means includes assessing means for assessing the image as to whether the image overall contains a function of the type of which the coded information is inserted and for assessing the degree of such parameter, and said correlation means is operative to correlate such assessments with the anticipated insertion.

57.   Apparatus according to claim 56, wherein the assessing means is arranged to assess a concave parameter.

58.   Apparatus according to claim 56, wherein the assessing means includes a masking parameter determination means for determining whether the strongly featured region is sufficiently well defined to have permitted insertion of coded information.

59.   Apparatus according to claim 53, wherein the decoding means is arranged to identify edge regions between areas of different luminance and/ or chrominance of each selected block.

60.   Apparatus for decoding an image according to claim 53, wherein the decoding means is arranged to identify textured regions having distributed therein localised areas of different luminance and/or chrominance values.

61.   Apparatus according to claim 60, wherein the decoding means is arranged to analyse a textured region of a field of the image by a process of cluster analysis, to identify a cluster of foreground local areas with a certain quality, and the decoding means includes an estimating means is arranged to determine whether there exists a modification of the chrominance and/or luminance values within a selected block corresponding to an insert function which decreases in intensity from its centre, for representing one of two binary values.

62.   Apparatus for decoding an image according to claim 61, wherein the estimating means is arranged to determine an insert function circular in extent, and centred on the geometric centre of the cluster.

63.   Apparatus according to claim 61, wherein the estimating means is arranged to determine along a length of the edge region an insert function whose intensity varies in a non-linear manner, for representing one of two binary values.

64.   Apparatus for decoding an image according to claim 61, wherein the estimating means is arranged to determine an insert function elliptical in extent, with its intensity gradually decreasing in a direction along its major axis, and with its major axis extending along the length of the edge.

65.   Apparatus for decoding an image according to any of claims 61 to 64, wherein the estimating means is arranged to determine an insert function which varies in intensity in a concave manner.

66.   Apparatus for decoding an image according to claim 61, wherein the decoding means and estimating means are arranged to select a subset of selected blocks, for decoding according to a pseudo random sequence, the blocks in the group representing one or more bits of information.

67.   Apparatus for decoding an image according to claim 53 wherein the decoding means includes assessing means for assessing the type of image within each selected block, whether it has a single strongly featured region, has several such regions, or is a block having low activity in terms of image information.

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68.   Apparatus for decoding an image according to claim 53 wherein the estimating means is arranged to detect a code inserted into a low activity block defined by a geometric region wherein the pixels within the region have a luminance modulated according to a predetermined function.

5   69   Apparatus for decoding an image according to claim 68, wherein the decoding means is arranged to detect a circular insert with a concave variation of intensity in a radial direction.

70.   Apparatus according to claim 69, wherein the strongly featured regions comprise edge regions between areas of different luminance and/or chrominance, or textured regions 10   having distributed therein localised areas of different luminance and/or chrominance.

71.   Apparatus according to claim 69 Or claim 70, including analysing means for determining in each block, weakly featured or background regions, and if identified, said detecting means is arranged to detect an appropriate insert function in such region.

72.   Apparatus according to claim 71, wherein the insert function is a relatively large 15   region having a constant or slowly varying luminance over its area.

73.   Apparatus for decoding an image according to claim 53, wherein the insert function is circular having an intensity which varies in a concave manner in a radial direction.
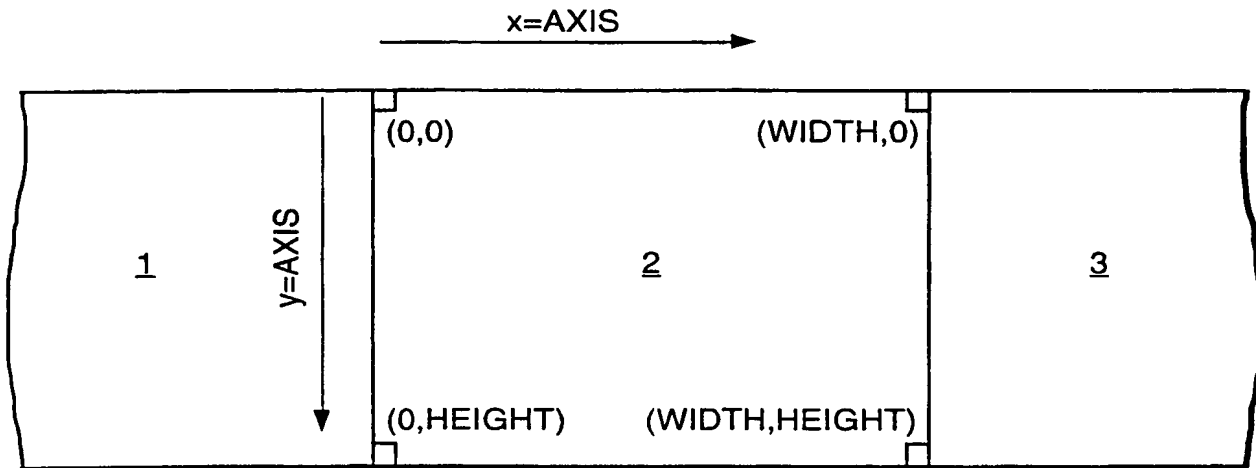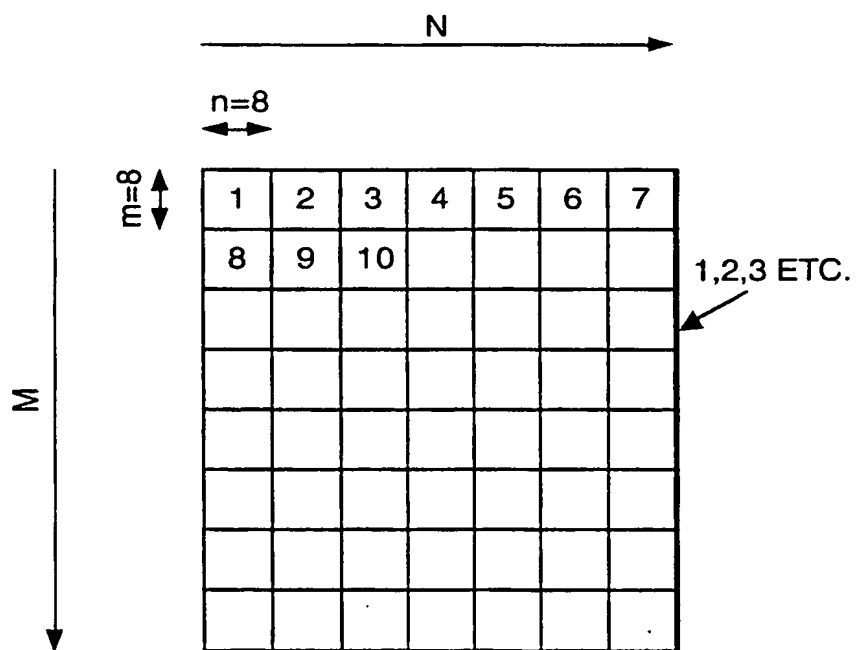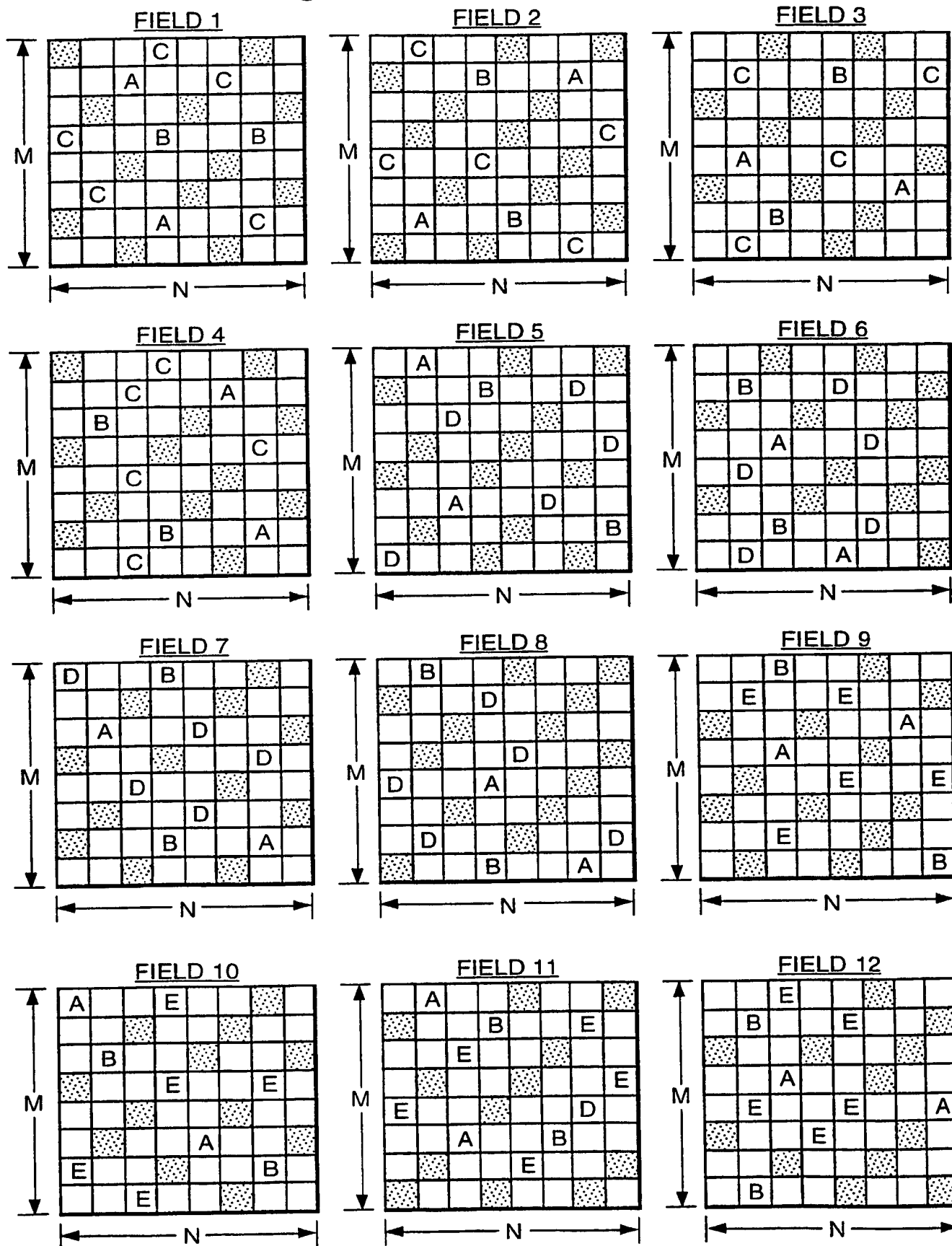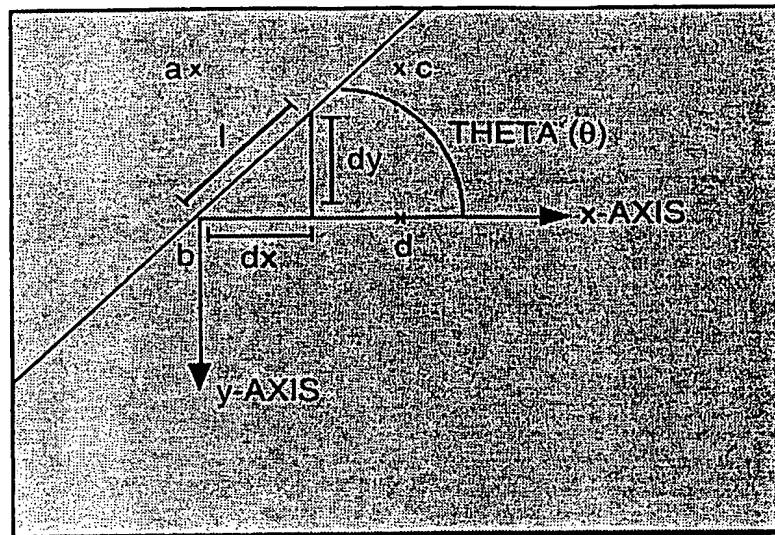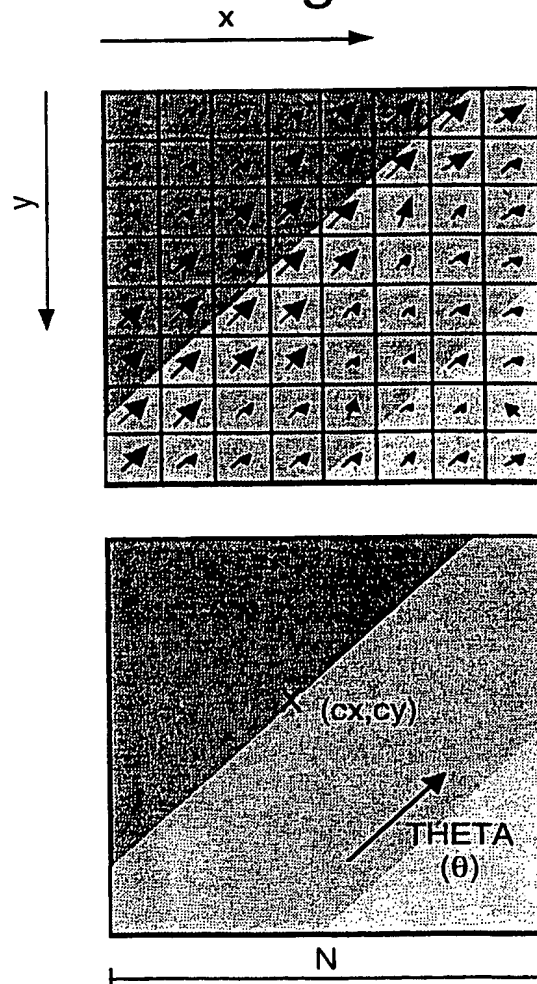
Fig.1.

x=AXIS →

Fig.2.

N →

3NSDOCID: <WO_____9841017A1_I_>

Fig.3.

Fig.4.

Fig.5.

Fig.6.

Fig.6a.

THETA (θ)
ORIENTED

Fig.6b.

LOW-PASS

Fig.6c.

INCONSISTENT

Fig.7.

Fig.8.

Fig.9.

VIDEO EMBEDDED CODING-
ENCODER-BLOCK DIAGRAM
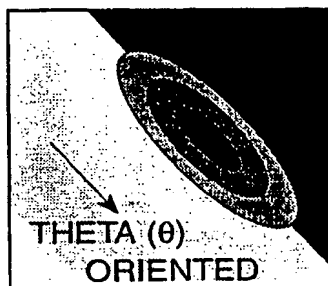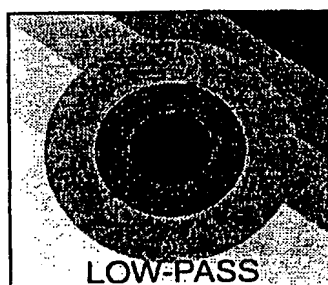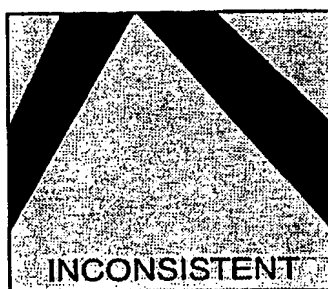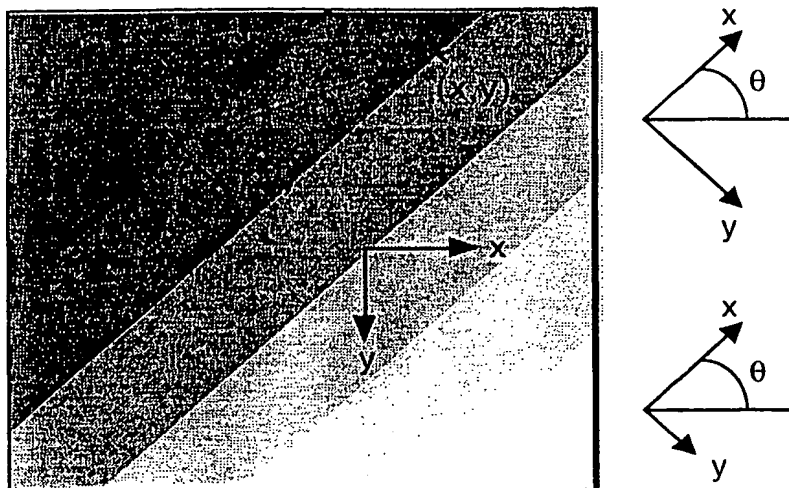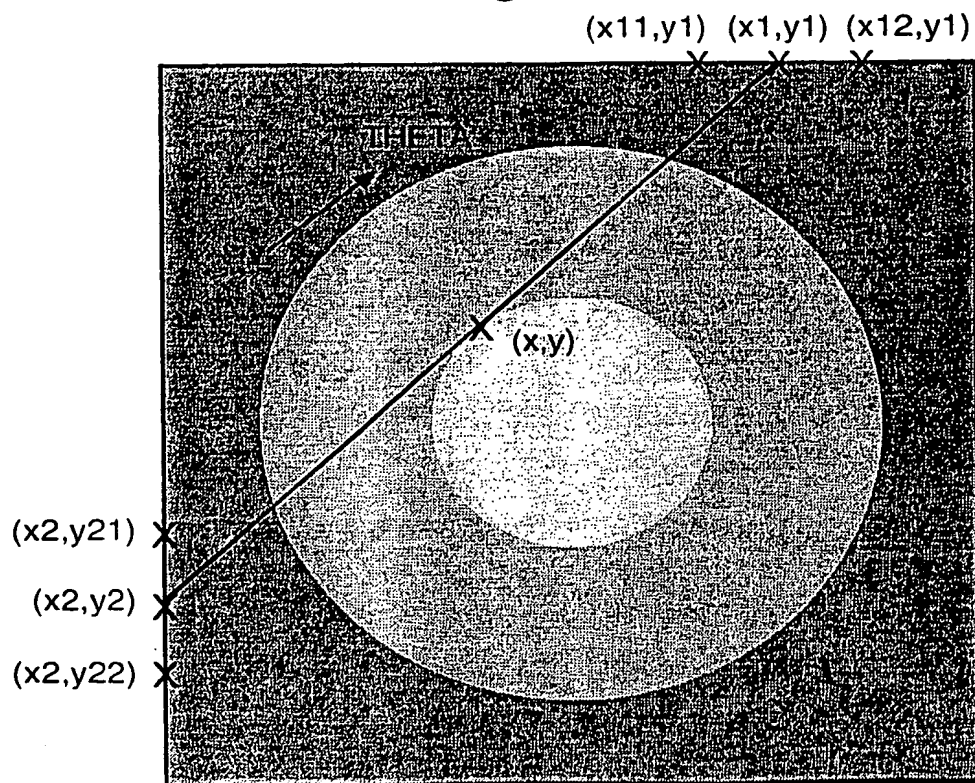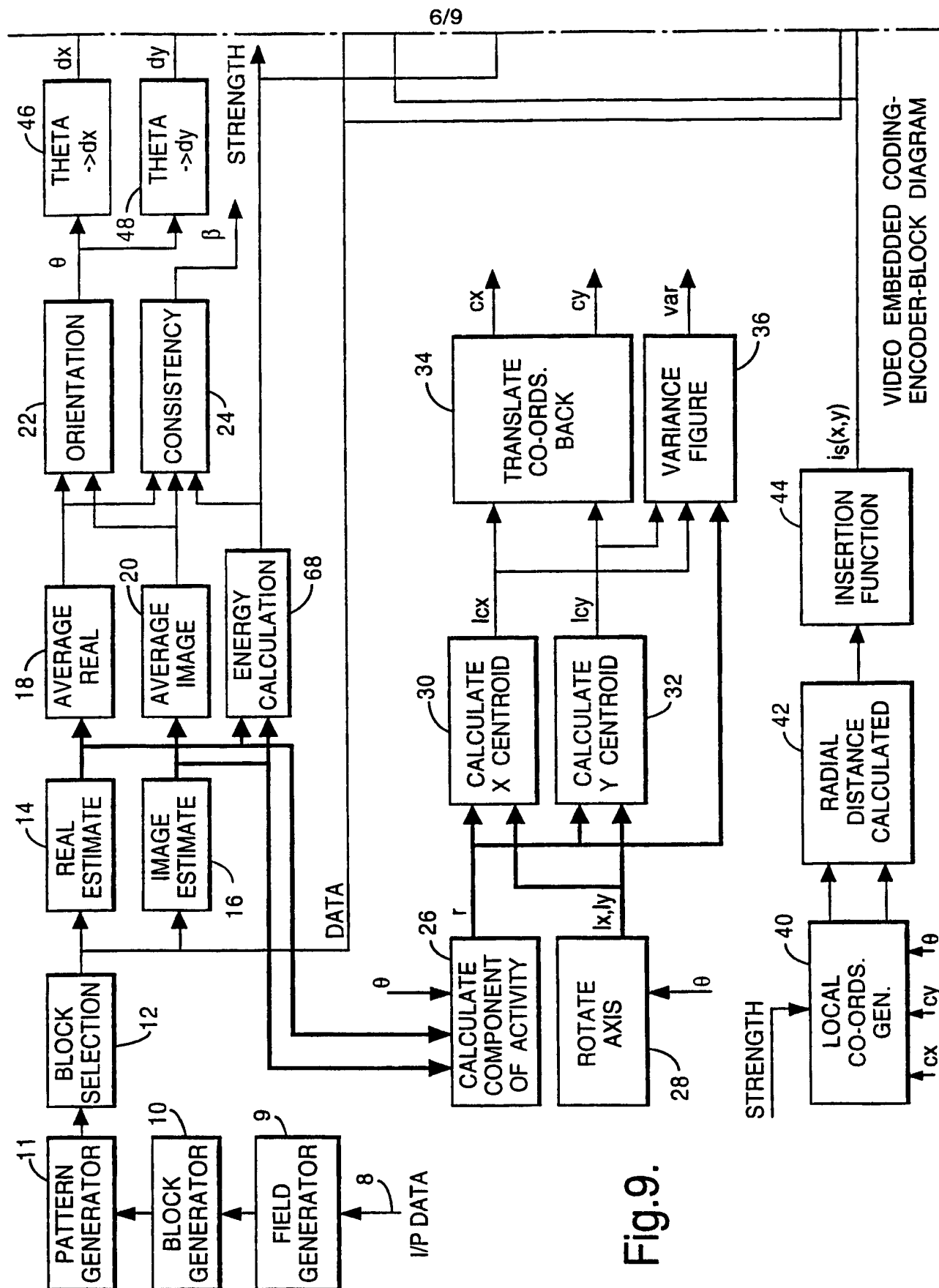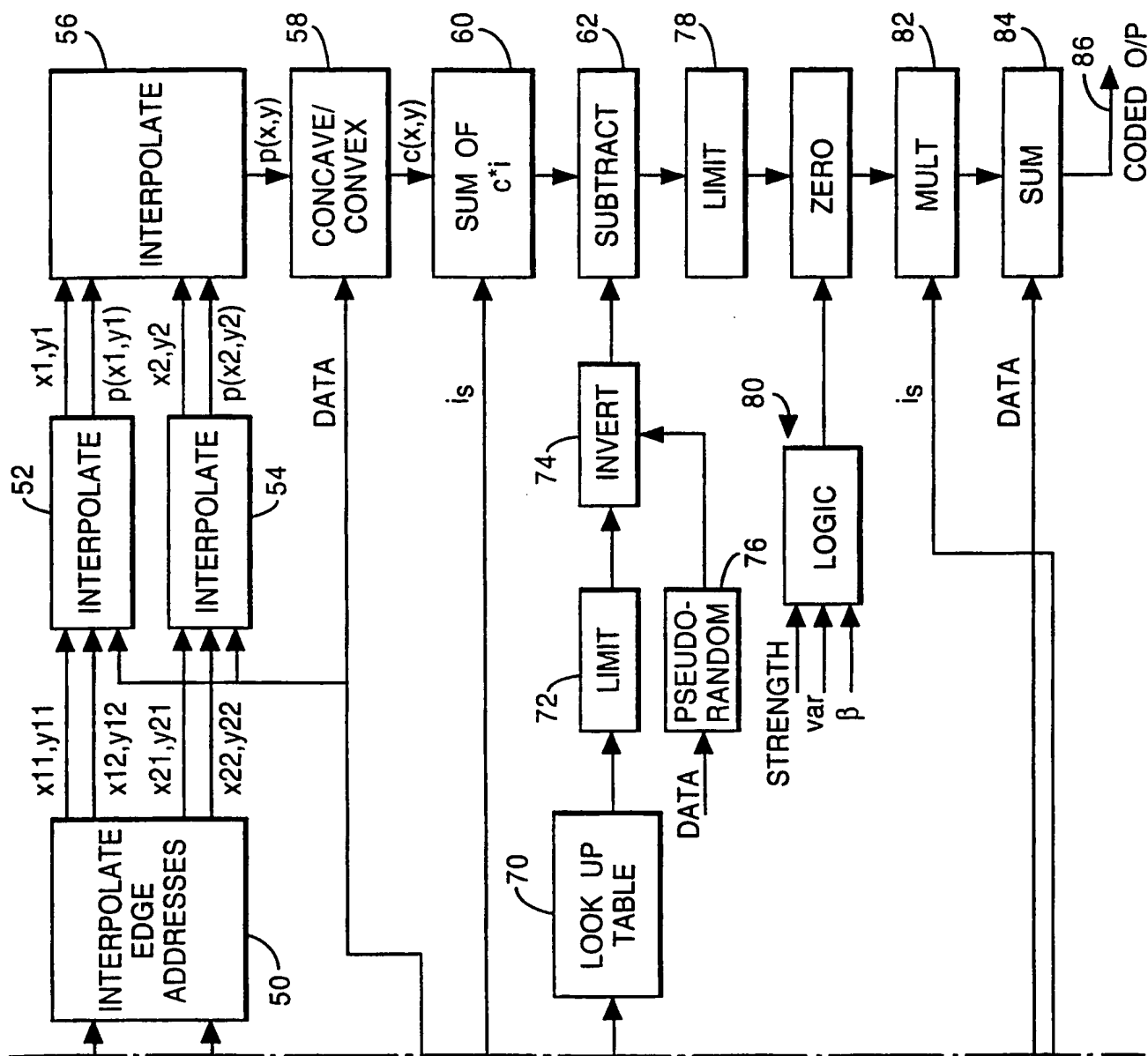
Fig.9(Cont).

Fig.10.

Fig.10(Cont).

BNSDOCID: <WO_____9841017A1_I_>

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6   H04N7/08

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6   H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 96 25005 A (TODD MARTIN PETER ;CENTRAL RESEARCH LAB LTD (GB)) 15 August 1996 cited in the application	1,2, 5-31, 34-54, 56-73
A	see the whole document ---	3,4,32, 33,55
Y	EP 0 360 615 A (DUBNER COMPUTER SYSTEMS) 28 March 1990	1,2, 5-31, 34-54, 56-73
A	see column 1, line 52 - line 62 see column 3, line 12 - line 20 ---	3,4,32, 33,55
P,A	WO 98 06216 A (TODD MARTIN PETER ;CENTRAL RESEARCH LAB LTD (GB)) 12 February 1998 cited in the application --- -/--	

| X | Further documents are listed in the continuation of box C. | | X | Patent family members are listed in annex. |

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Date of the actual completion of the international search	Date of mailing of the international search report
5 June 1998	18/06/1998

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document. with indication,where appropriate, of the relevant passages	Relevant to claim No.
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